THE LASER EXPERIMENTER

by Anthony Charlton

Welcome! We have an interesting module to build to add to the Lazerwave transmitter which was covered in detail in #LEdec93. The focus of this module is to enable remote monitoring of ionizing (as in potentially hazardous) radiation. Its sensor will detect Alpha, Beta, and Gamma radiation plus high energy X-rays.

Radiation physics always has an air of mystery surrounding it since we all seem to associate radiation with THE BOMB. However, there are many peaceful uses of radiation, too. Just a few examples include sterilization of food, instruments, and other mediums that may require sterilization but can't undergo heating or treatment with chemicals since it would produce an undesireable effect. Certain biological culture mediums would be an example of the latter.

Did you know radioactive material is used for generating electrical power aboard unmanned spacecraft? Some of our robotic spacecraft get far too deep into the abyss of space and distant from the sun to use solar power, and batteries are not practical to power such craft since their demand for energy is great. Plus, the lifetime of such missions are necessarily long, extending for years usually. In such cases, a radioactive material is contained aboard the spacecraft in a device called a THERMOELECTRIC GENERATOR where the decay of the material produces heat, which is then directed towards THERMOCOUPLES. They, in turn, utilize the PELTIER EFFECT which states that two dissimilar metals in intimate contact will generate electricity if heated. Interestingly, the effect can be used to cool materials as well, and by injecting current into the thermoelectric material one way it will become cooler, and by reversing the polarity it will become warmer.

Radiation is also used for inspection of metal castings for their integrity. And it finds its way into medical uses, as well. Now this isn't a promotional for advocating playing with radiation — we all know how dangerous it can be to living things — it's an introduction to a sensor that's able to send data about the quantity of radiation in a given area across a laser beam to a remote receiver, such as the {L}{A}ser {D}etector (LAD) presented in #LEsep93.

Figure 1 shows a block diagram of the system. The received data can be converted into the proper format and stored in a computer for analysis, or say translated to analog form and thus drive the pen of a calibrated chart recorder.

The modular radiation sensor is an instrument to be used where it might be unsafe for humans to monitor the amount of radiation, or where it's inconvenient to go, such as measuring the level of natural radiation on a mountaintop.

This sensor outputs three types of signals:

1) Audio — To headphones, as a click for each event detected.

2) Visual — LED output, which gives a brief flash for each event.

3) Digital — A CMOS level +9 V signal that ties into the DIGITAL input of the Lazerwave Transmitter. This signal may be adapted to a frequency counter and can be fed into a parallel I/O port of a computer with the proper interface circuitry.

CAUTION: The circuit, as shown, will not directly tie into an I/O card without causing irreparable damage to the card! MAKE SURE you translate the +9 volt CMOS logic level to a +5 volt DIGITAL level with the proper circuit BEFORE attempting to interface!

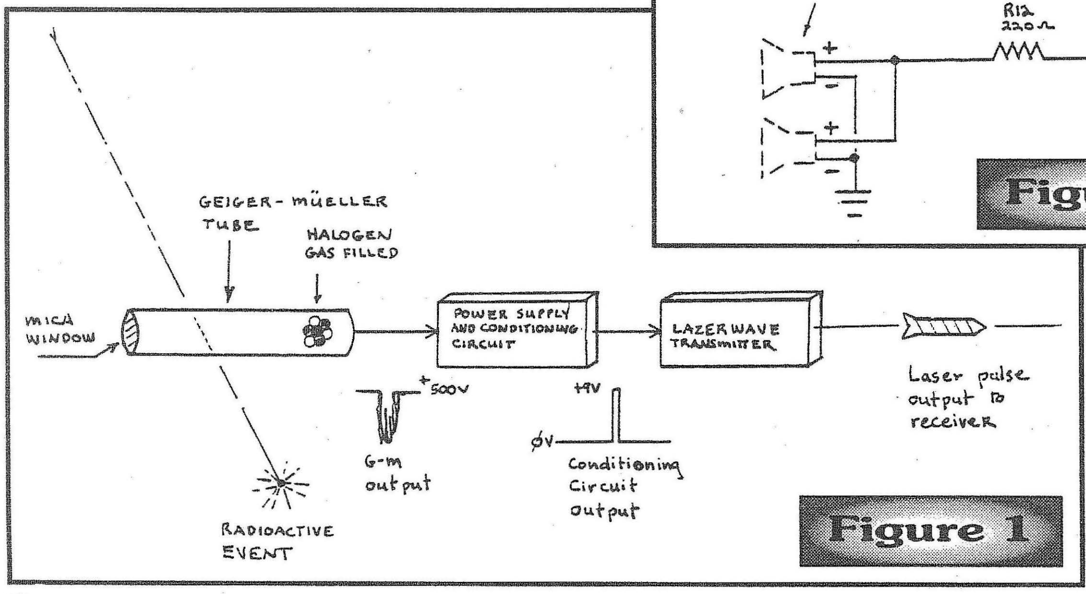

GEIGER-MÜELLER TUBE
HALOGEN GAS FILLED
MICA WINDOW
POWER SUPPLY AND CONDITIONING CIRCUIT
LAZERWAVE TRANSMITTER
Laser pulse output to receiver
+500V
G-M output
+9V
ØV
Conditioning Circuit output
RADIOACTIVE EVENT

Figure 1

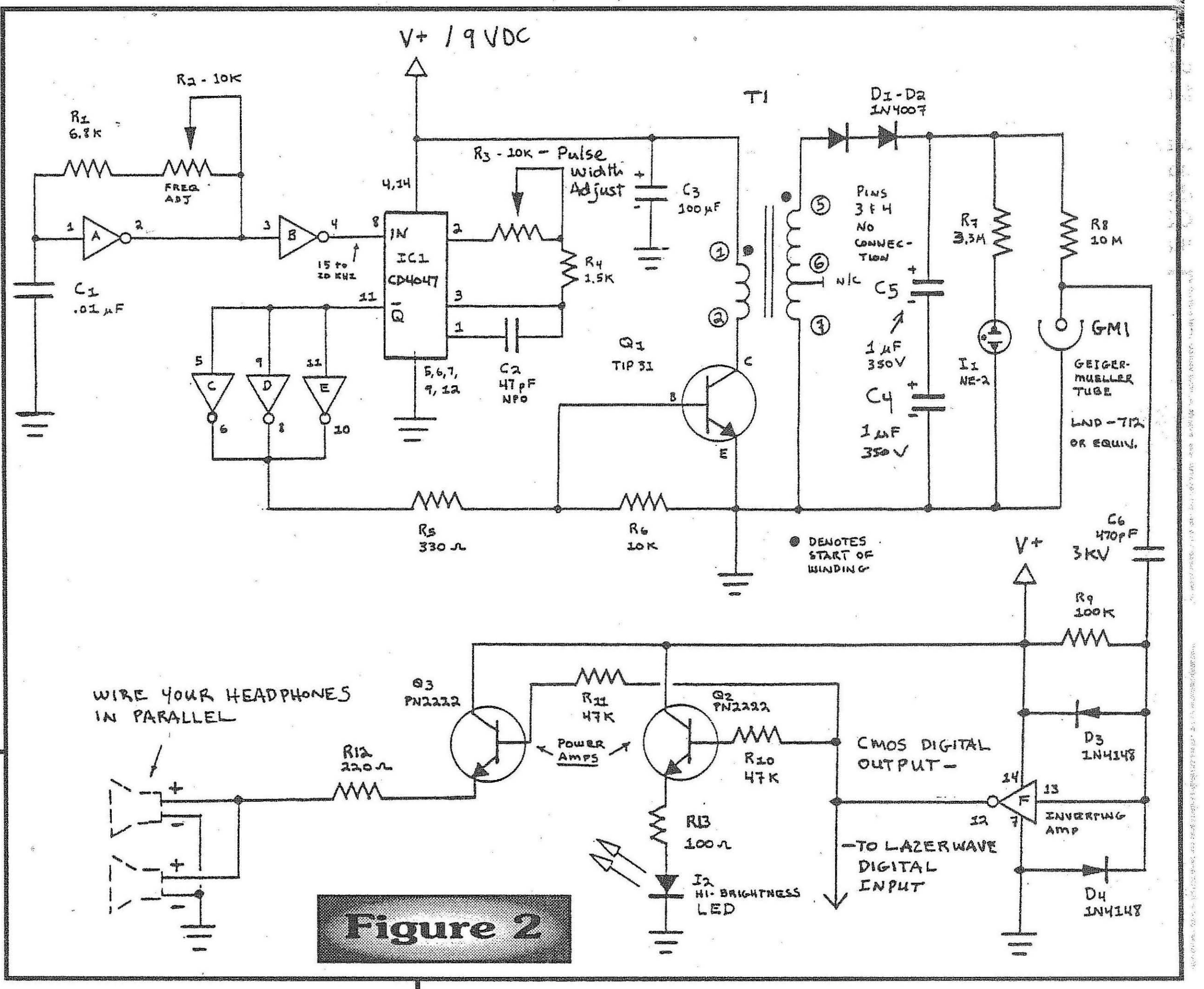

V+ / 9 VDC
R1 6.8K
R2 - 10K
FREQ ADJ
1
A
2
3
B
4
15 to 20 KHz
8
4,14
IN
IC1
CD4047
Q̄
11
2
3
1
5,6,7, 9,12
R3 - 10K - Pulse Width Adjust
R4 1.5K
C3 100µF
C2 47pF NPO
C1 .01µF
5
9
11
C
D
E
6
8
10
T1
①
②
⑤
⑥
③
Pins 3 & 4 No connection
N/C
D1-D2 1N4007
C5 1µF 350V
C4 1µF 350V
R7 3.3M
R8 10M
I1 NE-2
GM1
GEIGER-MUELLER TUBE
LND-712 OR EQUIV.
Q1 TIP 31
B
C
E
R5 330Ω
R6 10K
DENOTES START OF WINDING
C6 470pF 3KV
V+
R9 100K
WIRE YOUR HEADPHONES IN PARALLEL
Q3 PN2222
R11 47K
Q2 PN2222
POWER AMPS
R12 220Ω
R10 47K
R13 100Ω
I2 HI-BRIGHTNESS LED
CMOS DIGITAL OUTPUT—
—TO LAZERWAVE DIGITAL INPUT
14
13
12
7
F
INVERTING AMP
D3 1N4148
D4 1N4148

Figure 2

Circuit Theory:

This sensor module is based around a couple of simple building-block type sub-assemblies. Figure 2 shows the electrical schematic. They are: a hex Schmitt Trigger IC, which does several functions; a pulse-width modulated (PWM) circuit for precise power control; a miniature high voltage step-up transformer; the GM radiation sensor; and the output circuitry. We've labeled the Schmitt trigger with gates A-F to make it easier to follow through the circuit description.

Here's how the circuit works: Gate A oscillates at optimally 15 KHz to 20 KHz, the area where T1 operates most efficiently. The signal is fed into gate B, an inverting amp which generates a 50% squarewave. This, in turn, is adjusted in duty cycle by IC2, a monostable multivibrator. Potentiometer R3 and fixed resistor R4, along with the capacitance of C2, control the pulse width. The output from IC2, at its NOT Q output, is a pulse whose duty cycle is extremely high, with an OFF time of only about 200 billionths of a second (nS). This corresponds to a 99.2% duty cycle which is then inverted by gates C, D, and E into a signal whose ON time is about 200 nS and those three gates increase the current to the point where Q1 is efficiently switched. Thus we have pared the duty cycle from 50% to 0.8%.

Since the GM-tube needs only a few microamps to operate, this narrow duty cycle results in greatly conserving the battery life while still providing the 500 volts required to operate the GM tube. Rectifiers D1 and D2 convert the AC from the transformer's output into DC. Two rectifiers are used in series so as to provide adequate peak inverse voltage rating. C4 and C5 store a DC charge for the Geiger tube. I1 is an essential load for the secondary of T1; do not omit it, or else the voltage will creep up to a point where GM1 will be damaged or destroyed. Resistor R7 provides the small feed current needed to charge the GM's internal capacitance of about 3 pF to 500 volts, awaiting radioactive "events" — the blanket name of both particles or ionizing electromagnetic waves — for detection.

This kind of GM sensor has a man-made mica window that allows Alpha radiation to pass through for detection. Alpha cannot penetrate the steel shell of the tube otherwise. If you wish only to detect Beta, Gamma, or high energy X-rays you can use another type of GM tube sans the mica window provided you know its supply voltage. This mica window is VERY FRAGILE so don't touch it or bump it. If it breaks, the tube will be worthless.

When a radioactive event gets inside the tube, the molecules of the gases within react in an electrical avalanche manner, and many of them get ionized at once. If only one or a few became ionized, the resulting signal would be so weak it would be nearly impossible to detect. Hence the special gas mix, in which many molecules (I should guess billions of them, yet still a small fraction of those present inside the tube) become ionized at once and give us a detectable signal.

An event causes the tube to drop in potential between its center electrode at 500 volts and the steel shell, which is at ground potential. A pulse is thus generated which is passed via C6, and clipped in potential by high speed diodes D3 and D4 so that it will not destroy the input circuitry of gate F. R9 normally holds the input of gate F high, and thus its quiescent signal output is normally low at pin #12.

Once the signal from the GM tube reaches gate F, it is inverted into a single narrow positive pulse for each event detected. Amplifier transistors Q2 and Q3 increase the current of this pulse so that each time an event is detected, the LED will flash for a brief instant and a click will be heard in the headphones. The CMOS digital output is tied into the digital input of the Lazerwave transmitter; a block diagram is given at Figure 1 (Also see #LEdec93). *NOTE*: The Lazerwave transmitter will need to be turned on at all times in order to register and transmit each radioactive event. That is accomplished by tying the Lazerwave's "ON" input to V+ with a 1K resistor. Should you be unfamiliar with this project from the Dec '93 N&V issue, send any of your questions to the Laser Experimenter, P.O. Box, and an answer will be forthcoming, including circuit schematics where necessary — and it's free!

A RADIATION PRIMER

Radiation may be of two categories. NON-IONIZING RADIATION causes little or no change inside the atoms of the matter it encounters. For example, if one took a carbon dioxide laser beam, one could cut sheet steel with it, but it would not leave the steel radioactive. If the same beam were made of gamma rays, it would leave the steel radioactive since gamma rays are capable of stripping the electrons off the atoms, and changing them to charged particles called IONS. Therefore, gamma rays, being an IONIZING RADIATION, cause atomic changes in the hypothetical alloy's atoms and molecules.

Substances that emit radiation do so in a manner called HALF-LIFE, also referred to as RADIOACTIVE DECAY. For example, if you took one pound of an imaginary substance that decayed by 1/2 in exactly one year to a substance that had no radioactive property (in other words, a stable substance), half its atoms would still be radioactive after one year, one-fourth after two years, one-eighth after three years, and so on.

In the real world, such behavior is not so simple. Substances decay from one element (or compound) into another radioactive one in what is usually a complex chain of decay with each element having its own half life. Frequently, several types of radiation are being emitted simultaneously until a stable element is finally reached, given time. The shorter the half-life, the more radioactive the element is. One pound of an element that has a half-life of a million years may not be dangerously radioactive (at a reasonable distance), but if its half-life were one year, it would be very dangerously radioactive indeed.

Ionizing radiation has its energies measured in Mega Electron Volts or MeV. The more MeV, the more penetrating power the particle has. Ionizing radiation may be particles or electromagnetic waves of high energy. Particles and waves of the same MeV behave differently, however. An Alpha particle of 4 MeV can be stopped by a sheet of paper, whereas an X-ray (an electromagnetic photon which can be thought of as a wave) of 4 MeV could pass through solid steel.

The difference is Alpha radiation is rapidly attenuated by collison with molecules of the substance it travels through, even air. On an atomic scale, this is like the deflection achieved while playing billiards, so you can see why Alpha particles are quickly stopped. By comparison, the X-ray could be thought of as an ultra high speed microscopic shock wave that would weave right through the billiard balls.

ALPHA PARTICLES consist of two protons and two neutrons with a total atomic weight of four, and is equivalent to the nucleus of a Helium atom. Alpha particles have a positive electrical charge, and are radiated by many radioactive substances such as Radium, Uranium, Thorium, and the Americium 241 in your ionization smoke detector. At sea level, Alpha particles travel only about four inches in air.

BETA PARTICLES also called Beta "Rays," are energetic electrons emitted by many radioactive substances (example: Strontium 90) that travel at a fraction of the speed of light. Beta particles can damage living tissue, altering the genetic code within, and causing disease if in sufficient quantity. They travel easily through the air.

X-RAYS are energetic photons with no electrical charge or mass that travel at the speed of light. They can penetrate matter proportionately to their energy level. X-rays are actually extremely short wavelengths of light and are an electromagnetic wave and not a particle. The shorter the wavelength, the higher its energy level. X-rays range from "soft" or long-wavelength types that are used for medical X-rays, to "hard" short-wavelength types that can pass through metal, and are frequently used for inspection of metal castings.

GAMMA RAYS are extremely energetic photons with no electrical charge or mass that travel at the speed of liht. Gamma rays are very damaging to tissue. They are emitted by some radioactive substances (example: Cobalt 60), explosive and other nuclear devices, and nuclear power plants. They pass easily through the body and are stopped only by thick layers of soil, concrete, lead, or other dense material.

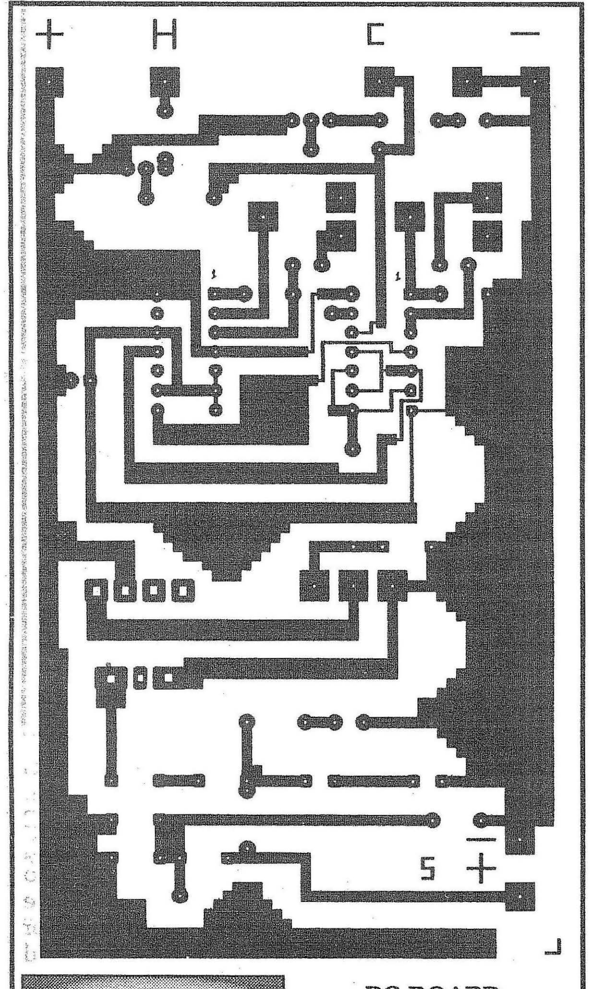


Figure 3 PC BOARD FOIL SIDE

Putting It Together

To ease assembly, we have provided a PC board pattern and Parts Placement Guide at Figures 3 and 4, respectively. Locate the GM tube ahead of the control electronics. You could use a discarded microphone case to house the GM tube within. To protect the fragile mica window, you can use plastic flyscreen in front of it. This will cut down on your Alpha detection accuracy; as it appears under the microscope flyscreen is about 20% netting and the rest open space. Alpha will bounce off this netting or be absorbed, so take this into account. Most Beta and X-ray, and all Gamma events will get through the netting.

Make sure the orientation of the polarized components is correct or the circuit will not function. Build all of the circuit except leave off the costly GM sensor until correct functioning can be verified. Now, set potentiometers R2 and R3 to midpoint. Attach a new 9 volt alkaline battery (or 9 volt regulated power supply) to the circuit. I1 should come on right after power is applied. If it didn't check for the following:

- Polarity of the polarized components.
- Integrity of the PC board's traces and soldered connections.
- T1's functionality. The primary should read a fraction of an Ohm, and the secondary roughly 150 Ohms. T1 may have been damaged during installation.
- Check the oscillator and PWM sections of the circuit with an oscilloscope or logic probe. In the former case, you should clearly see the waveforms as previously described and in the latter, your logic probe should show a "Pulse" reading at both test locations.

You may have to "tweak" the setting of R3 to get enough power to light the lamp. However, if this is so, probably C2 is below the value it's supposed to be, and not allowing enough of a pulse width to correctly drive T1 and its associated components.

Testing The Radiation Sensor

To peak the efficiency of the supply, we need to find a "notch" in T1's operating frequency that produces the correct voltage for the least battery current draw. R2 and R3 may be adjusted so only 15-20 mA will be drawn off a 9 volt battery. Power up the circuit without the GM sensor attached, and adjust R2 and R3 until the input current is the least with 500 volts on the output. Consider the input resistance of your voltmeter will affect the reading, as the current at this voltage is actually only in the microampere range.

The easiest way to check the voltage accurately is to watch the readout of the voltage meter, and touch the probe to the hot side of C5 and quickly note the reading. You may have to do this several times for each adjustment to get an accurate reading. Don't worry if the voltage is a little high, as the operating voltage for this model tube lies between 400 and 600 volts, but don't go above 600!

Once you have the circuit calibrated, turn off the power and attach the GM sensor. Use cable that can withstand the 500 volt operating voltage. RG-58U shielded cable is ideal. Take care not to overheat the GM tube while soldering or you may destroy it.

Next, obtain a radioactive source for testing. This is not so hard, as Coleman gas lantern mantles have a small amount of Thorium in them that emits Alpha radiation and the GM tube can easily detect this. Remove the mantle from its wrapper (the Alpha particles won't get through the plastic wrapper) and bring the mica window close to the mantle. You should hear random clicks in the speaker and see the LED flash. An old watch dial may also contain a small amount of Radium, which the tube will pick up. Some scientific supply house also carry mildly radioactive rocks or other sources of emission which are used in demonstrating cloud chambers which visually record the tracks of particles inside them.

Expect some random clicks to persist in the detector. This is normal, and is called BACKGROUND RADIATION. It is the result of natural sources such as Uranium in the earth's crust and the events that are generated in the earth's atmosphere as high energy particles from space collide with air molecules. At my lab, the background count with this tube averages 11 per minute. Should you have an abnormally high count like 40 or so per minute, you may have a problem

SOURCES

LNS Technologies, 20993 Foothill Blvd., Suite 307, Hayward, CA 94541. Inquiries: (510) 886-9296; orders: (800) 886-7150. Visible laser diodes and a driver kit, also carries a line of high-technology electronic kits. Accepts major credit cards. Catalog $1.00.

MWK Industries, 1269 West Pomona, Unit 112, Corona, CA 91720; ph: (909) 278-0563, FAX: (909) 278-4887 Hours: 8-5 PST weekdays, 10-3 Saturdays. Free catalog. Source for new and used laser equipment, supplies and optics. Carries a wide variety of He-Ne and other lasers suitable for the experimenter & hobbyist.

Allegro Electronic Systems, 3 Mine Mountain Road, Drawer NV, Cornwall Bridge, CT 06754. Supplies laser and science-related technical books, experimenter-level laser communication & data acquisition kits; plans, specialized equipment, and hard-to-find electronic parts. Catalog $1.00. Inquiry FAX line: (203) 672-0123, seven days/week.

Anderson Lasers, Inc., 2883 West Royalton Road, Broadview Heights, OH 44147. New and surplus industrial and scientific lasers & equipment. Carries high-power commercial grade equipment, not a hobbyist supplier. Professional inquiries contact: Richard Anderson, ph: (216) 237-6629 or FAX: (216) 237-0656.

Images Company, P.O. Box 140742, Dept. N, Staten Island, NY 10314; ph: (718) 698-8305. Carries holography supplies, optical components, components for laser power supplies, stepper motors.

Edmund Scientific Company, 101 East Gloucester Pike, Barrington, NJ 00807-1380; ph: (609) 573-6250; FAX: (609) 573-6295. Free catalog. Supplier of a wide variety of educational and scientific equipment including lasers and an extremely comprehensive line of optics.

Midwest Laser Products, P.O. Box 2187, Bridgeview, IL 60455; ph: (708) 460-9595; FAX: (708) 430-9280. Free catalog. Carries new and used laser equipment and inexpensive start-up systems.

Digi-Key Corporation, 701 Brooks Avenue South, P.O. Box 677, Thief River Falls, MN 56701-0677; ph: (800) 344-4539; FAX: (218) 681-3380. Free catalog. Top quality electronic parts supplier.

Herbach & Rademann, P.O. Box 122, 17 Canal Street, Bristol, PA 19007; ph: (215) 788-5583; FAX: (215) 788-9577. Free catalog. An excellent experimenter source for quality mechanical, optical, electronic, and electromechanical surplus.

Be sure and mention Nuts & Volts when you contact the above suppliers so your request goes to the right department.

and should check it out.

This sensor can detect Radon gas that can leak into your home from cracks in the basement walls, spaces around pipes, and sometimes even from your fresh tap water. Should you suspect Radon, contact your local branch of the EPA for literature regarding testing and reduction methods.

Oh the Joy of Visible Laser Diodes!

After some months of searching, I've found a Solid State Laser Diode Kit that is both reasonably priced and can be easily put together and operated without the fear of blowing out the static sensitive laser diode.

Such a kit is offered for $89.00 plus $5.00 shipping from LNS Technologies who is listed in the "Sources" box. To me, this is cheap (well, I did have to save for it a bit — who says laser experimenters are rich, eh?). Just a few years ago, I remember the diode alone cost $200.00. What this well thought-out kit features is a 3 milliwatt red visible diode contained in a transparent cylindrical case.

The kit is powered by a wall plug-in transformer which generates a DC current, but the kit can be run from batteries too, as we'll see in a moment. One drawback of visible diodes is the extreme sensitivity to static charges and overvoltage and/or current. LNS has solved this by the design of their unique circuit. This is shown at Figure 5.

Note the laser diode and photodiode in one package, as shown by the dotted lines. The internal photodiode monitors the output of the laser diode on a dynamic basis, and converts some of the light output from the back of the laser to a current. This signal is converted from a current to a voltage by U1-A and its associated components, including current set potentiometer R11. U1-B is a differential amplifier which amplifies the difference between the voltage of Zener diode D2 and the voltage from U1-A. That voltage is proportional to the light output of the laser diode. Transistor Q3 is then turned on by this voltage, and supplies the current to drive the laser diode. Resistor R1 limits the maximum current that can be supplied to the laser diode. Capacitor C5 and resistors R3 and R4 serve to filter, and hence stabilize, the feedback portion of this circuit.

An additional soft-start circuit is used to prevent sudden and potentially destructive application of current to the diode. This is comprised of C2, C7, resistor R8, and PNP transistors Q1 and Q2. When power is first applied to the circuit, both Q1 and Q2 are biased off by the voltage at the base of Q1. As R8 discharges the capacitors, Q1 and Q2 turn on and allow current flow through the laser diode. Thus, the soft start circuit forms something like an electrical "gate" that will allow the current to flow. The delay, which appears to be about 1 second total, allows time for the output from the voltage regulator U2 and the feedback circuit to stabilize before current is applied to the laser diode.

To me, this kit is a good value since:

1) It's a brand new laser diode with an estimated life of 100,000 hours.

2) The kit is complete with everything. All you need are simple assembly tools like a soldering iron and wire clippers (*Hint: buy a dedicated pair of toenail clippers; they are cheaper than wire cutters and work great for clipping the leads off components after they are soldered in*), but you WILL need a digital multimeter to calibrate the circuit once it's built. Inexpensive DMM's can be found at Radio Shack and are obtainable from advertisers in Nuts & Volts.

3) The manual is very thorough and easy-to-understand.

4) The mini-PC board is excellent quality, tinned for ease of soldering, and silk-screened for component placement outlines.

5) The laser beam is focusable. Simple optics are included so you can spread the beam or focus it to a pinpoint. For precision applications like focusing the beam into a small fiber optic, one will have to use an additional double convex lens to get proper focusing.

6) Enough information is contained so you can understand the circuit and repair it yourself if needed. For the beginning electronic/laser enthusiast, LNS offers a repair service where they will fix any reasonable assembly errors for $10.00, unless of course, the laser diode is damaged or destroyed.

7) I like building good kits!

Observations During Kit Building

It is helpful to read each step once before you do it. Why? To clearly understand what is expected. Then, read it again and perform it. In some cases, I hurried and got into confusion about a step, but that was my fault for trying to build the kit a little too fast.

I thought some parts were missing at first, but instead found them stuck inside to the adhesive of the laser diode package. Everything listed was accounted for after this find. The parts were contained in four small plastic bags which had labels on them listing their contents. I thought this was a great idea, and it really cut down on the time to look for a component.

One suggestion is, packaging could be improved upon by labeling the part number as well as its value on the content label. But if there's any mystery, a complete part and component value list appears in the manual.

A magnifying glass is strongly suggested as an assembly aid. The little 1/8 watt resistors included with the kit have color coded value markings on them, and they're hard to see without magnification.

One possible source of confusion: the polarity of electrolytics is marked at the negative with a white stripe on the component itself, while the silk-screened pattern on the PC board and the Component Placement Guide are marked for the POSITIVE side of the 'caps. This could cause some trouble for the first-time kit builder. Make sure that the correct orientation is used when installing the electrolytic capacitors or they'll heat up and blow up on you when power is applied.

On step #15, an LED is installed. While this step indicates you can identify the polarity of the LED by a flat spot next to the cathode lead on its lens (most LEDs are like this), I couldn't find any flat spot, and hence used the diode check function on a multimeter to identify the cathode. It is the shorter of the two leads of the LED.

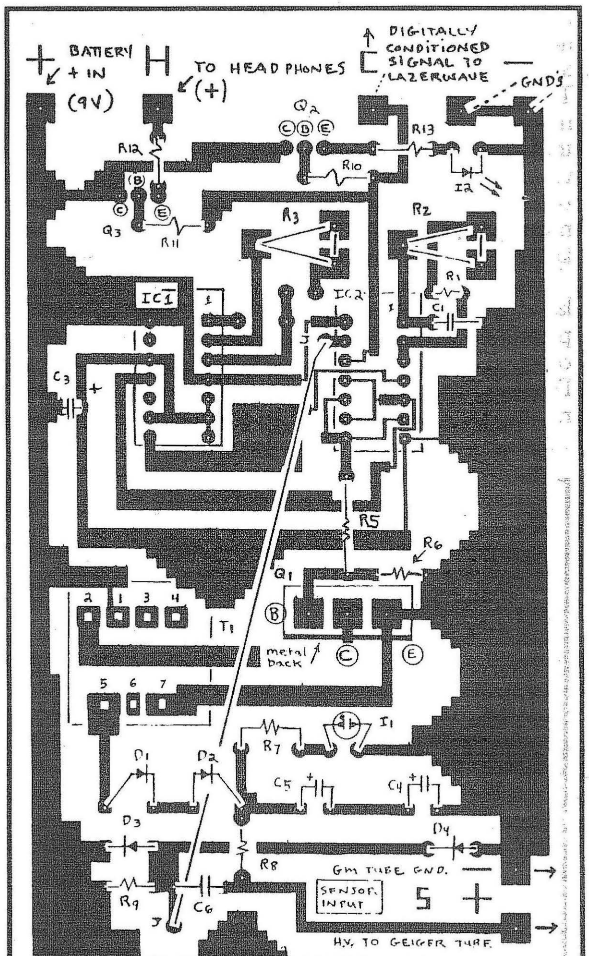
Next, installing the jumper post in step #17 was a little difficult; evidently the spacing of the two pins of the post don't precisely match the PC board hole spacing. However, this problem was easily solved by installing the post upside down, and once it was soldered in, sliding the plastic joiner down the pins until it matched the position depicted in the illustration for this step.

When the kit is finished, it's time to calibrate it to the proper drive current for the laser. Here the instructions say to set the current at 85 mA, and that careful adjustment of the drive current potentiometer R11 will allow an exact figure, but for the life of me, I couldn't get the diode to fully lase until it hit 90 mA. At lower currents, it wasn't bright enough, then at 90 mA it kicked into full brightness and you could see it doing this as the beam was projected onto a piece of paper. **(NEVER LOOK INTO AN OPERATING LASER!)**

After checking some mfr. data about this, I decided to leave the setting at 90 mA and I don't believe it will damage the diode over time. Absolute maximum drive current rating for this diode is 100 mA, so it's rather close. However, I measured the output on a photometer, and found the diode was emitting 6.2 mW — twice what it's supposed to, so the guess is this diode was a little out of 'specs to begin with.

As we've mentioned before in this column, semiconductor laser diodes have a fairly broad tolerance of 'specs compared to some other types of semiconductors. But set the current at 85 mA if you can.

Two minor instruction oversights: number one is I couldn't find the step for installing the current-control potentiome-



Parts Layout

Figure 4

Note: Long Jumper (J-J) Parts appear like you have X-Ray Vision.

ter, R11. I suggest installing this BEFORE working with the laser diode, so again, any static charges from your soldering iron won't risk the diode. Oversight number two is LNS listed in the Application Section, that the kit can be used for laser communications and holography. The first application is difficult, since I wouldn't recommend modifying the circuit so it can be electrically modulated. However, there is a way around this which we'll see in a moment.

Holography is out though, since laser diodes of current technology have a physical property called COHERENCE LENGTH where the light waves are essentially all in phase in this length. This length must be long enough so in the beam path of your holographic set-up, the light waves are likely to remain in phase throughout the beam path or the hologram won't come out.

Laser diodes have a short coherence length of only about 1 mm according to one expert in holography, so making holograms with them is exceedingly difficult, if not impossible, he warns us. But there are plenty of other applications for this laser, such as light shows, beam-break burglar alarms, weapon alignment, various displays and experiments, and, not the least, it functions as a fine laser pointer.

My overall impression of the solid state laser kit was it's an excellent kit, well worth purchasing, and will be a welcome addition to the laser experimenter's lab.

This kit may be operated on batteries by the following method: Since it contains a negative voltage regulator, the LM7908CT, a DC input up to -35 volts is permissible for that component — HOWEVER, at high input voltage, the heat dissipation will be too great without attaching a heatsink to the regulator. This would be difficult, as all the components fit inside a 1" diameter tube. So the ideal battery supply would be a 12 volt rechargeable. Connect the negative terminal of the battery to the center terminal and the positive to the body of the jack.

As far as externally modulating the laser, you can do this by affecting the plane of polarization, by using interferometery principles like with the Vibration Detector sensor (#LEnov93) or by AM modulating it. In the last case, I used a common piezoelectric transducer with a small, lightweight mirror glued to it. An audio signal was fed into the transducer, and the signal modulated the beam and was recovered with the aforementioned LAD receiver. While the quality isn't as good as direct modulation, it was adequate for demonstration purposes.

Polarization modulation is probably out of our reach as of the moment, but I'm working on it. If the beam is first passed through a polarizer, then through a medium whose plane of polarization can be made to rotate in proportion to the amplitude and electrical polarity of the modulation current, the beam is brightened or dimmed by this method as the axis of the polarizer and polarizating medium shift in and out of phase with each other. Hence, this produces AM modulation (brightening and dimming varying with the amplitude and polarity of the modulation signal) of the beam as the wavefronts interfere with each other.

There are two types of polarization modulation I'm aware of. One is called a KERR CELL and it consists of a cavity filled with a liquid whose plane of polarization can be affected by a magnetic field. Typically, such a cell has many turns of wire wound around it so that a strong magnetic field is set up by the input signal in the liquid medium. Benzene, nitrotoluene, chloroform, and other chemicals are used, but these are poisonous and exceedingly difficult, if not impossible for the experimenter to get ahold of because of that reason.

The other method is similar, and involves passing the beam through a semiconductive crystal whose polarization plane is changed by a current supplied by electrodes. Lithium Niobate ($LiNbO_3$) is used in laboratories, however, crystals of this substance are very difficult to find and are expensive. I am currently working on a project where a crystal of Potassium Sodium Tartrate Tetrahydrate, a.k.a. Rochelle Salt ($C_4H_4KNaO_6 * 4 H_2O$) is being grown to attempt this latter method of polarization modulation. This chemical is relatively easy to get ahold of and costs only about $15.00 a pound.

Rochelle Salt has a large piezoelectric effect, thus the application of current causes a relatively large displacement in its physical size. Also, it's not poisonous as so many other substances that will crystallize are. It is reasoned that this crystal will cause both a polarization modulation and an interferometric modulation.

As a second experiment, the modulated beam will be mixed with an unmodulated reference beam, and as the crystal changes its size, in ratio to the electrical polarity and amplitude of the input signal, the two beams interfere with each other, thus creating modulation. My goal is to achieve through-the-air laser transmission of video. The main problem at this point is to grow the crystal as pure and defect-free as possible. This isn't so easy with the fluctuations of temperature occuring in the lab in winter!

Once a proper crystal is grown, I have a friend with a diamond saw who's offered to cut the crystal across, top to bottom, and through at various angles. One of these angles will achieve maximum piezoelectric effect, but may require considerable experimentation to find the right angle.

We shall see whether this experiment works or not in the future, and which of the two methods of modulation (polarization or interferometric) works the best. People wishing to duplicate this experiment are cautioned not to ingest this or any chemical, or handle the solution or crystals without using gloves. Also, Rochelle Salt is hygroscopic, meaning it will absorb moisture from the air. I plan to encase the crystal once it's grown in a small plastic box containing a desiccant to absorb any moisture. **NV**

Next month we shall have a look at some everyday applications of lasers like — alerting us to intruders!

Closing Quote: "I've been in the inventor business for 33 years, and my experience is for every problem there is a solution."
— Thomas A. Edison

Suggestions for future columns, questions, constructive criticisms, and laser-related material are most welcome. Send all to: The Laser Experimenter, P.O. Box 74, Cornwall Bridge, CT 06754. We would like to publish letters in "Reader Feedback" occasionally. Indicate if using your name and address is OK. Individual replies to questions regrettably are not possible due to time constraints, but we will answer some questions in the column.

PARTS LIST

All resistors are 1/4 W, 5% carbon film unless otherwise specified.

Resistors

R1 — 6,800 ohm
R2, R3 — 10,000 ohm, laydown style trimmer potentiometer
R4 — 1,500 ohm
R5 — 330 ohm
R6 — 10,000 ohm
R7 — 3.3 Meg-ohm
R8 — 10 Meg-ohm
R9 — 100,000 ohm
R10, R11 — 47,000 ohm
R12 — 220 ohm
R13 — 100 ohm

Capacitors:

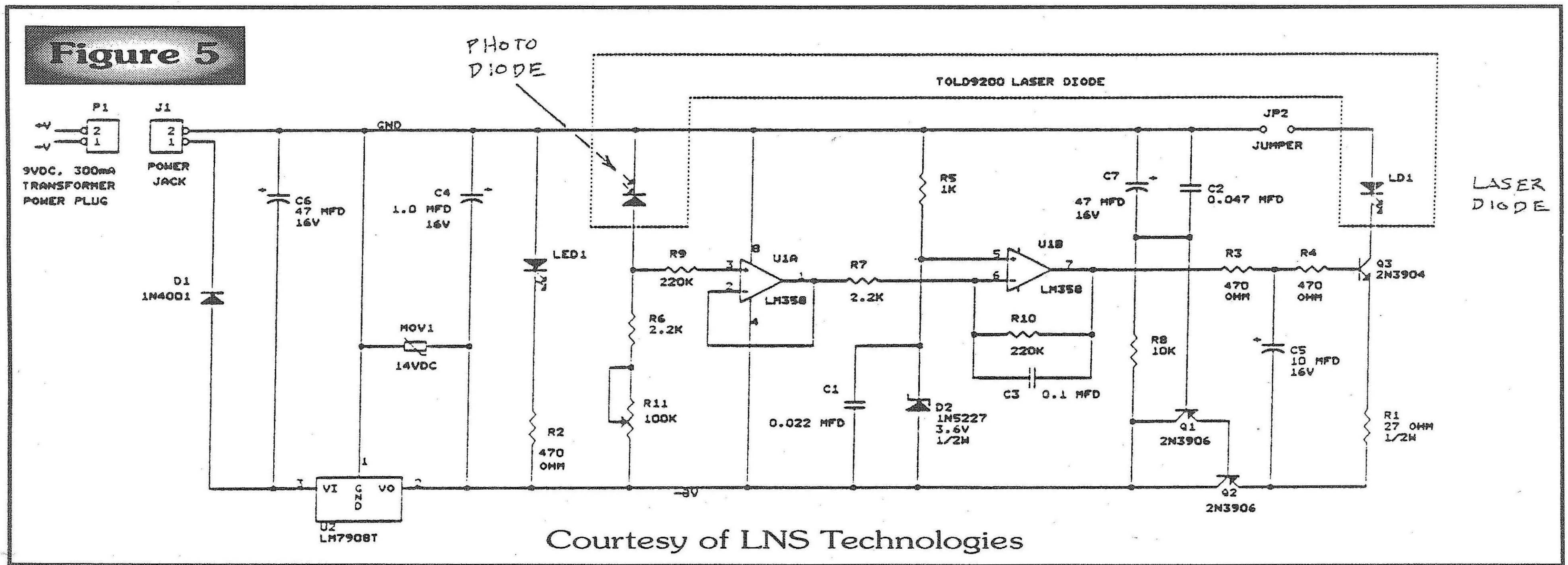
C1 — .01 uF polyester or Mylar
C2 — 47 pF NPO type ceramic disc or polyester, 5% tolerance
C3 — 100 uF, 16 WVDC electrolytic
C4,C5 — 1 uF 350 WVDC electrolytic
C6 — 470 pF 3 kV

Other Parts:

GM1 — Geiger/Mueller radiation sensor tube, Allegro #GM-712, LND #712 or equivalent
I1 — NE2 Neon lamp
I2 — Ultrabright LED
T1 — Ferrite core step-up transformer, Allegro #COR-2B or similar
Q1 — TIP 31-A, -B or -C
Q2,Q3 — PN2222
D1,D2 — 1N4007
D3,D4 — 1N4148 high speed switching diode
IC1 — CD4047BE monostable multivibrator
IC2 — MM74C14N hex CMOS Schmitt trigger
2 — 14 pin IC sockets

Most of the parts can be supplied by: Digi-Key Corporation (see Sources). The GM1 tube ($45.00), COR-2B ($3.99) and C4-C6 ($2.99 for the three) are available from Allegro Electronic Systems as are other components of the Lazerwave System (see Sources). Add $3.50 for shipping and handling. Address your order to Drawer #L. Allow 30 days for order delivery.

Figure 5



Courtesy of LNS Technologies

THE LASER EXPERIMENTER

by Anthony Charlton

Welcome! As we get further into the science of lasers, we discover that specialized components are used. The same is true of all facets of science and technology. This time, we'll introduce some of these optics by building an important optical component ourselves to add to our bag of Laser Experimenter tools. This device will be used in this and next month's project (which I am going to keep a secret until it appears).

I think a lot of readers of this column have built the basic tools and projects presented since The Laser Experimenter began in June. At least that's the tide of the letters received here. If you haven't yet, it's not too late to jump on the band wagon. This way, you'll gradually accumulate a laser laboratory, and will be able to do many, many things with your laser.

Regarding optical components, so far, we've touched on simple lenses, mirrors, and beamsplitters. But did you know industry uses some very exotic kinds of lenses and windows? A window is the optical component that seals the laser tube off from the environment. It must be as clear as possible at the laser's output wavelength. Interestingly, due to its long infrared (IR) wavelength, glass can't be used with carbon dioxide (CO2) lasers. Whatever percentage is not transmitted is absorbed. CO2 lasers are used to MACHINE glass; note it readily absorbs CO2's 10,600 nanometer (nm) wavelength. So, if I used a glass lens to focus a strong CO2 beam, it probably would explode it!

This problem is solved by using special materials to make lenses out of that don't absorb energy at the wavelength of the laser in question. Ordinary optical glass or Pyrex can be used for all the visible wavelengths, and it will also work fine with near infrared. But once the wavelength starts getting absorbed, one has to resort to materials such as Gallium Arsenide, Germanium, Zinc Selenide, Magnesium & Calcium Fluoride and Sodium Chloride as lens and window materials.

Despite their easy transmission of the high powered, invisible, infrared CO2 laser beam, making and using lenses shaped from such materials can be a problem. Some of these materials are poisonous, and others like Calcium Fluoride and Sodium Chloride absorb moisture from the air, so they have to be used in a dry environment. Synthetic Sapphire is another exotic material. Optical components fabricated from these materials are VERY expensive, compared to glass.

Ultraviolet (UV) lasers share the same problem. The short wavelength of UV lasers won't go through common glass, as it readily absorbs the wavelength like it does IR. This is due to the nature of the glass on an atomic scale. Note Figure 1. Curve A is for optical glass. Note how UV transmission falls off sharply beginning at about 370 nm, also called "soft" UV. Curve B is for synthetic fused silica. It performs well until about 250 nm – this is "hard" UV – the kind that burns your skin. Curve C is for a special ultraviolet grade synthetic fused silica. It works well to about 170 nm. That wavelength is so energetic that it is useful for such things as etching integrated circuit wafers. Much shorter, and you'd have X-rays! Quartz and synthetic silica are the commonest material used for UV work although diamond and synthetic sapphire are used as well.

More about optics in our next column ...

Build a Corner Cube Mirror

A corner cube mirror is more correctly called a RETROREFLECTOR. First, surface mirrors must be used in this project. Now what makes this mirror different is that light can enter it at any front angle the mirror will accept, and that light is returned to the source. Figure 2 shows the GEOMETRIC CONCEPT. This, for a corner cube, is not a triangle but resembles a full six-sided cube that has been divided in half along its edges. Everyday examples of a retroreflector are road signs and the strips of reflective material sold to put on kid's bikes, etc., to make them visible at night.

These retroreflectors are arrays of glass or plastic beads that are adhered to a backing material. When light strikes the beads, it is reflected back to its source, but in the case of the road signs, it is deliberately not a perfect retroreflector or else the light would be returned to the headlights of your car, and you wouldn't see anything reflected. Our retroreflector will be as perfect as we can make it, returning the light to the laser in a straight line (we hope!). Deviation from the perfect return is measured in ARC-SECONDS, one arc-second being 1/3600th of a degree. A degree is one 360th of a circle, so you can see when they are spec'd to say, 2 arc-seconds, this is one precision optical component!

In order to make this alignment as perfect as possible, you have to have a jig which has sides that are at right angles (90 degrees) to each other. I used the corner of a steel block that had been surface ground, but since most people won't have such a jig, improvisation is necessary. Try using something cubic like dice. Coat them first with a thin layer of melted paraffin so the adhesive won't stick everything together. Tape the three mirrors together over one corner of the jig, and apply a little Krazy glue. The capillary action of the glue will bond the edge surfaces. Another idea is to cut the corner off a box and glue the mirrors inside the corner. A square, new, sturdy box is essential here.

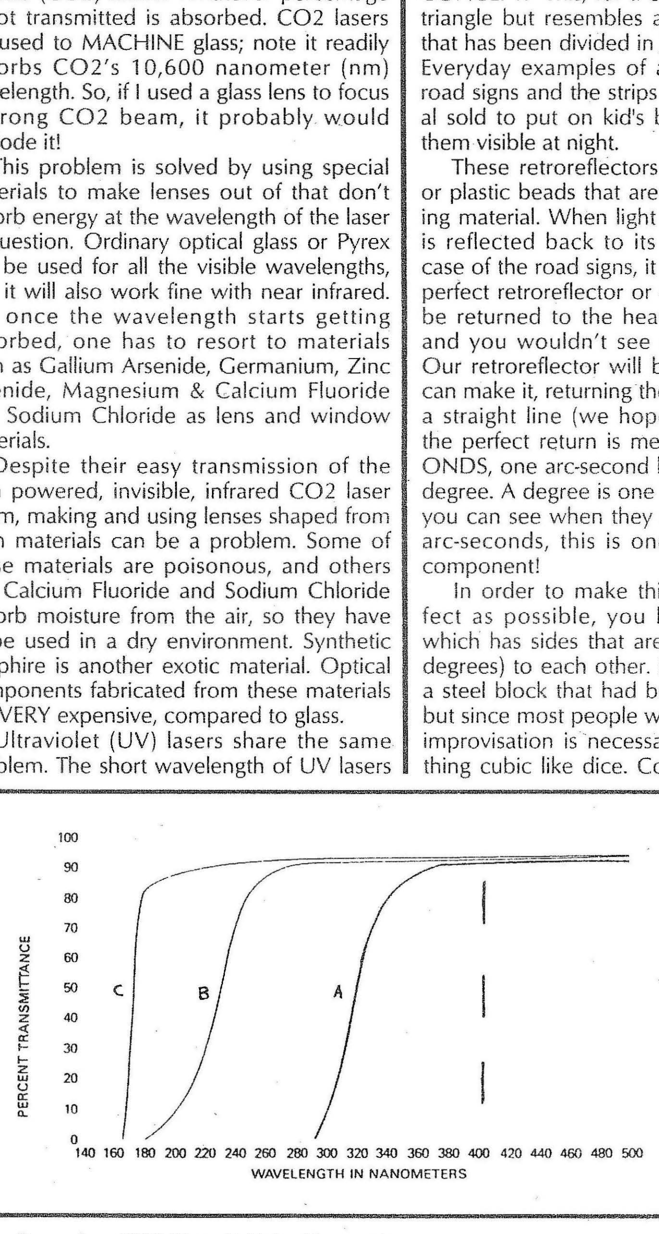


FIGURE 1.

Broken line is beginning of ultraviolet spectrum.

Make up several retroreflectors. You will use the most accurate one in our project. If the beam is returned within 1/2" to the laser after 20' of total path travel, you're doing a good job. The mirrors can be pulled apart should the alignment be poor. Fine Wetordry sandpaper, 400 grit or finer, can remove the glue remnants so you can re-use the mirrors. Commercial retroreflectors start at $100 apiece, so who cares if a few aren't perfect, eh? MWK Industries carries surplus mirrors adequate for this experiment. Teachers may want to purchase a precision retroreflector from Edmund Scientific, who has the best prices on them I can find for you.

To use the corner cube mirror, you have to have the beam bounce off all three sides. An easy rule to remember is this: point the apex of the back side of the mirror at your face. Now turn it around and look at the bottom of the apex. You can always see your eyes looking back at you, no matter where you point your head, as long as you look at the bottom of the apex. You want the junction of the mirrors to look at the laser. Now, remember that the laser beam wants to hit one side of one mirror, and bounce off the other two sides. That way, it'll always return to its source. If the alignment of the mirrors isn't perfect (and don't worry if they're not) by turning the mirror, the reflected laser spot will move on a distant object. Yet, it is about a 1000% improvement over trying to align a flat mirror.

Retroreflectors have been placed on the moon by Apollo astronauts. Lasers are periodically fired at the array from observatories who measure the precise distance from the Earth to the Moon. It's been claimed that distance can now be tracked within feet!

Build the Lazerwave Transmitter

The Lazerwave Transmitter is a system that can transmit either analog or digital information over a laser beam. It has several sub-modules that we shall build in succession in the upcoming months. These modules are capable of transmitting data from temperature, radiation, and explosive vapors. An additional module will transmit your voice from a sound-operated "bug." You can also hook-up anything you want to the circuit to obtain data from such sending units as humidity or a seismometric – as long as the data can be converted into a digital signal or an analog signal whose frequency variances contain your desired information.

Three on-board audio tones are provided to facilitate optical alignment. A suitable receiver such as the companion Lazerwave Receiver that appeared in the September '93 issue of Nuts & Volts is recommended. A 780 nm semiconductor diode laser is the heart of the transmitter. I have not yet tried using a 670 or 635 nm laser diode, as they are too expensive to risk at this point. The 780 nm infrared laser diode works well, is slightly visible in a darkened room, and it will show up easily if you have Nightvision goggles or a B&W CCD camera whose IR filter has been removed.

With the latter arrangement, you can make a VCR tape of the transmitter in action like I did. You may also use a high powered infrared LED, but expect lesser range. Even with a visible LED, we were able to hear music out to 100' in broad daylight using a 300 millicandela red LED lamp and a DCV concentrating lens on the receiver. When you think of that, it's rather remarkable considering how great the beam dispersion of an LED is.

Calculating the intensity using the Inverse Square Law, the LED will be only 1/10,000th as bright at 100' than at one foot. Using a lens on the transmitter should extend the range to at least 1000'. Range of a mile is not uncommon using a collimated laser. In our mountainous area, we either have to take a field trip to get to an area clear of trees, or stand in the middle of a long stretch of Route 7 and communicate by hand signals while dodging cars, so we really don't know how far this circuit will go! We'd appreciate hearing from any of you who build this circuit, and what range you were able to get.

Description of the Transmitter Circuit

Figure 3 is the transmitter circuit. To understand how it works, we must first go over specifications of semiconductor lasers. The most important ratings are: THRESHOLD CURRENT abbreviated I(th); OPERATING CURRENT I(op); OPERATING VOLTAGE V(op); and OPTICAL POWER OUTPUT P(o). All these parameters are further classified under factory specs as "Minimum, Typical and Maximum."[1] Unfortunately, there is quite a wide tolerance between minimum and maximum! The builder is cautioned that he may have to adjust the milli-amperage of the transmitter circuit to compensate.

A common type of laser diode, the Sharp #LT020MC, has a typical I(th) of 50 mA. That means laser action begins at 50 mA, and below it the diode acts simply like a high-power LED. I(op) is rated typically at 65 mA at P(o) of 3 milliwatts (mW), the normal operating power of this device. P(o) can be up to 5 mW @ 100 mA with this part, but it is not recommended to "push" the diode to its maximum output.

Why? Semiconductor lasers contain tiny mirrors which are critical to developing laser output. These micro-mirrors can be permanently damaged by excessive output, which occurs around maximum I(op). The result will be greatly reduced output or destruction, even if the P(o) is excessive for a microsecond. Remember, although the beam is not that powerful, the area from which it emits is only about a thousandth of an inch wide and a third as tall. This results in incredible optical densities – sometimes exceeding a million watts per square inch.[2]

I(op) for different diodes may range from 30 mA to 100 mA or so, depending upon type. The last spec, V(op), is the voltage drop across the laser during operation. A typical value is 1.75 volts. V(op) must be considered when calculating component values for the drive circuit. Be certain you have adequate 'specs for your laser before constructing this circuit – it makes no sense to destroy an expensive component for lack of proper data.

Now more detail of the transmitting circuit. The most important parts are a CMOS 555 timer and a DIP switch bank. Switches S1 and S2 control the frequency of an onboard audio tone, generated both to facilitate optical alignment and to operate an optional encoded electronic lock such as the laser operated model rocket launch controller that appeared in the November '93 column. Switches S3 and S4 are used to select whether the timer operates as a free-running oscillator, its ANALOG information transmission mode; or as a monostable multivibrator (one-shot) which is its DIGITAL data transmission mode.

ANALOG mode is used to carry voice or music and other linear time-variant data. This mode is initially used to align the system. DIGITAL mode conveys sensor information as pulse bursts from the laser which results in the most power and transmission efficient manner possible. However, the built-in audio tones are disabled by this mode.

The transmitter operates by sending short pulses instead of having the laser on continuously. Since the laser is active only part of the time regardless of which mode it is in, power consumption is greatly reduced. This generally does not reduce the capture ability of the receiver, since it 'sees' only the peak power of each pulse. Further, in the monostable mode, the width of the pulses can be widened if reception conditions require it by switching in S1 and/or S2. This improves reception under adverse conditions with some sacrifice in battery life.

IC1 is driven from an alkaline 9 volt battery or REGULATED DC power supply. It is IMPERATIVE that ONLY a CMOS 555 timer be used, as bipolar timers generate spikes called CROWBAR CURRENTS that may destroy the laser. These spikes may run up to 400 mA for a brief instant of 200 nS across the supply rails every time the timer changes state. Very bad for laser diodes! Q1 switches the laser. It is a special type made by Zetex, and was selected for its small collector-emitter voltage drop (0.25 V), tiny size and large current handling capability.

Let's examine the ANALOG mode. Considering the R1/R2 ratio shown, the UNMODULATED pulse width is fixed at 30% on-time regardless of frequency output. Normal operating frequency in this mode is 100 KHz – suitable for modulating with voice and music. Modulations change the center frequency and on-time pulse width percentage according to polarity and amplitude; the manner is similar but not identical to frequency modulation (FM). It is these changes we hear when the signal is received and the carrier frequency filtered out. This method of impressing information on the beam is far less affected by light intensity changes than with amplitude modulation (AM).

Components C6 and R4 are used to couple external modulation to IC1. Any AC signal up to about 5 volts peak-to-peak can be used. For audio or music modulation, I had excellent results connecting it to a cassette player's earphone jack. Surprisingly, the system reproduced high-fidelity music better across free air than at the player itself!

During optical path alignment, switches S1 and S2 now come into play. With S1 on, capacitor C3 is added into the astable timing circuit and the frequency drops to 7.6 KHz, an audible area. With S2 on and S1 off, capacitor C4 is added into the circuit, and the frequency rises to 9.1 KHz. With both S1 and S2 on, all three capacitors are now in parallel and the frequency reduces to 4.3 KHz.

When in DIGITAL mode, a single output pulse is produced for each input pulse. An R-C input network consisting of R5 and C7 adjusts all input pulses, regardless of initial length, to a narrow triggering pulse. The duration of the output pulse is equal to 1.1 RC and is normally 6.5 microseconds. Should the input pulse exceed this length, the output pulse is simply as long at the input pulse. This helps out when using this design for input pulses that come infrequently, like from a radiation detector. At least in that case, we hope not too much input will occur!

Our receiver will be more accurate due to this built-in feature. Designers wishing to decrease the input pulse width may do so by reducing the values of R5 and C7. Conversely, if either component is increased in value, the input pulse will be longer in width. If needed, C3 and C4 may also be switched, in which produces the following output pulse widths: C3 alone = 85 microseconds, C4 alone = 71 microseconds, C3 + C4 = 150 microseconds.

You can choose any combination of S1 and S2 that provides the minimum error at the receiver – just remember the longer the output pulse width, the lower the frequency that can be transmitted in the digital mode. For instance, at a 150 microsecond pulse width, the maximum useful digital input frequency would be about 6500 Hz and exceeding that would mean the laser would jam continuously on and data could not be recovered.

Resistor R3, a 1 watt unit, limits the peak current through the laser and must be carefully chosen. With our prototype, a safe value of 75 mA I(op) current was selected. This is determined by measuring the voltage drop of the two transistors in the circuit first. Next, you subtract the drop across the diode which is usually 1.75 volts. This gives us a 6.75 volt drop required, which with a 91 ohm resistor will work out to 74.2 mA or very close to our chosen value.

Capacitor C5 shunts any switching transients generated by IC1 to ground, thus protecting the sensitive laser diode. Since diodes are destroyed by static charges, precautions must be taken during assembly to eliminate these. The same holds true for voltage spikes from the power supply, etc.

A problem we have to contend with is weather. Rain, snow, fog, dust, or smog can seriously attenuate the beam. Operation under such conditions is improved with a longwave infrared laser (904 nm or longer) whose beam is not as readily attenuated by particulates in the air. Careful alignment of the optical elements and increasing the gain of the receiver helps to overcome such problems, but it is unrealistic to expect good reception during adverse weather.

The optics should be shielded to prevent contamination from weather in any case, as anything affecting the focus of the optics, such as dirt or water on the lenses, will degrade performance. Builders living in the south may have problems with flying bugs who hatch out in swarms in the summertime. Their wingbeats will modulate the beam, and result in disruption of information if Lazerwave is used for analog transmission. In this case, locate the system on poles – above the normal flying altitude of these little pests.

To operate the Lazerwave, you set the DIP switches as follows according to the mode you want to transmit in. It is best to test the system using an LED first, and make sure all functions properly before risking a laser diode:

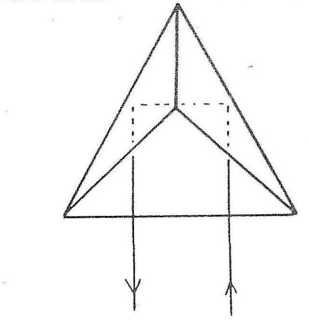
	ANALOG	DIGITAL
S1	off	on
S2	on for testing tone	off
S3	on for testing tone	off
S4	on	off
S5	off	on
S6	on	off

We have provided two PCB patterns for you. The first is a 2x blow-up of the foil side of the board and appears at Figure 4. A copy shop can transfer this pattern to Mylar film for making a board from, if you make PC boards using a photographic method. Just be sure and reduce it exactly 50% so the parts fit. The second pattern, at Figure 5, shows the parts placement. Note this is also a foil side pattern. Parts appear like you had X-ray vision, and pin #1 of IC1 is in the upper right corner.

Since some of the traces are quite fine, you will have to go easy on the heat while soldering, or else the traces will lift. Watch out for solder bridges with this pattern. If you get all the parts from DigiKey, they will just fit. 1/8th watt resistors may be used as well, and save a little more space.

You will find the completed Lazerwave is only about as big as a matchpack! Should

FIGURE 2.



Geometric representation of retroreflector.

LASER NEWS AND DEVELOPMENTS

Crystals Used To Modify Laser Colors

One of the most interesting uses of optics with lasers is the capability of crystals to shift the frequency of laser light. Long revered by people as a source of metaphysical power, crystals made of compounds such as lithium niobate and beta-barium borate have been found to possess the capability of doubling, tripling, quadrupling, or creating other multiples of the fundamental frequency of the input beam.

Scientists have taken advantage of this controllable, well-defined property. For instance, in a recent experiment conducted by researchers P.N. Kean and R.W. Standley of Amoco Technology Co., in conjunction with G.J. Dixon of CREOL, two infrared laser beams were combined in a crystal that shifted the frequency into blue light at 459 nm. One may ask what use such an experiment is, yet IBM has been interested enough to create blue laser light using a crystal, since the shorter wavelength will be able to store five times more data on an optical disk than the infrared diode lasers currently used can. Crystals used in this way are referred to as NON-LINEAR OPTICS. While helium-cadmium and argon lasers generate light in blue wavelengths, the prospect of a compact, cheaper laser not requiring a high voltage power supply and bulky gas storage reservoirs is attractive. It will be the technology of the future, and it's in the laboratory now.

Lasers that generate green light from input beams in the infrared are actually quite common in industry circles. An interesting fact is if the frequency is doubled, the output power in watts is halved, but the energy is retained since shorter wavelengths have more energy. Some power is lost to absorption and optical effects of the crystal like refraction and reflection, but conversion efficiencies of 90% or better are possible with some combinations of crystals and colors. In time, it may become feasable to generate laser light over the whole visible spectrum with a tunable system.

The possibilities of a full-spectrum laser are fascinating. Consider some medical uses. Imagine being able to tune a laser so that at one color, it can painlessly blast away unwanted tatoos or birthmarks, while at another, it can perform surgery on the eye or shatter kidney stones without harm.

With the right frequency, lasers can be used to profile the sea bottom or communicate with satellites. One idea that was raised – a holdover from the Strategic Defense Initiative – is to fire lasers from the ground at satellites that are in earth's shadow, thus enabling a recharge of the onboard batteries normally topped up by solar power. This would increase the working life of such satellites. In order to accomplish this, one must choose a "window" in earth's atmosphere – a point where absorption is minimal and maximum power could be delivered to the satellite. Only by precisely tuning the wavelength of a laser to one of these windows can the beam travel through the atmosphere with minimum loss.

By changing the color of the laser beam, materials processing can be facilitated, since each different material will absorb different bands of laser light. This becomes very important when one is seeking to say, write data on an optical disk. One material may work efficiently at absorbing the laser light at one color during the write cycle, and poorly at another, leading to read errors in the data. Diverse effects are also true on an atomic scale, where physicists are manipulating small groups of atoms and even single atoms using lasers in an effort to better understand the secrets of nature and to search for ways to create new materials and chemical compounds. Although the specific technology is hard to understand – non-linear optics is chock full of exotic terms such as "mode-locked oscillator" and "self-phase modulation," the point is that, like with communication equipment, when you change the frequency, you change what the equipment can do. Like the difference between a FM radio, a TV receiver, and a microwave oven is simply a matter of increasing the electromagnetic frequency and how you put it to use. One can hardly imagine what the future holds in the light show department . . .

Source: August 1993 Laser Focus World

SOURCES

MWK Industries, 1269 West Pomona, Unit 112, Corona, CA 91720; ph: 909-278-0563, fax: 909-278-4887; hours: 8-5 PST weekdays, 10-3 Saturdays. Free catalog. Source for new and used laser equipment, supplies, and optics. Carries a wide variety of He-Ne and other lasers suitable for the experimenter & hobbyist.

Anderson Lasers, Inc., 2883 West Royalton Road, Broadview Heights, OH 44147. New and surplus industrial and scientific lasers & equipment. Carries high-power commercial grade equipment, not a hobbyist supplier. Professional inquiries contact: Richard Anderson, ph: 216-237-6629 or fax: 216-237-0656.

Allegro Electronic Systems, 3 Mine Mountain Road, Drawer NV, Cornwall Bridge, CT 06754. Supplies laser-related technical books, experimenter-level laser communication & data acquisition kits; plans, specialized equipment & hard-to-find electronic parts. Catalogs $1 for a set. Inquiry fax line: 203-672-0123, 7 days/week.

Edmund Scientific Company, 101 East Gloucester Pike, Barrington, NJ 00807-1380; ph: 609-573-6250, fax: 609-573-6295. Free catalog. Supplier of a wide variety of educational and scientific equipment including lasers and an extremely comprehensive line of optics.

Midwest Laser Products, P.O. Box 2187, Bridgeview, IL 60455; ph: 708-460-9595, fax: 708-430-9280. Free catalog. Carries new and used laser equipment and inexpensive start-up systems.

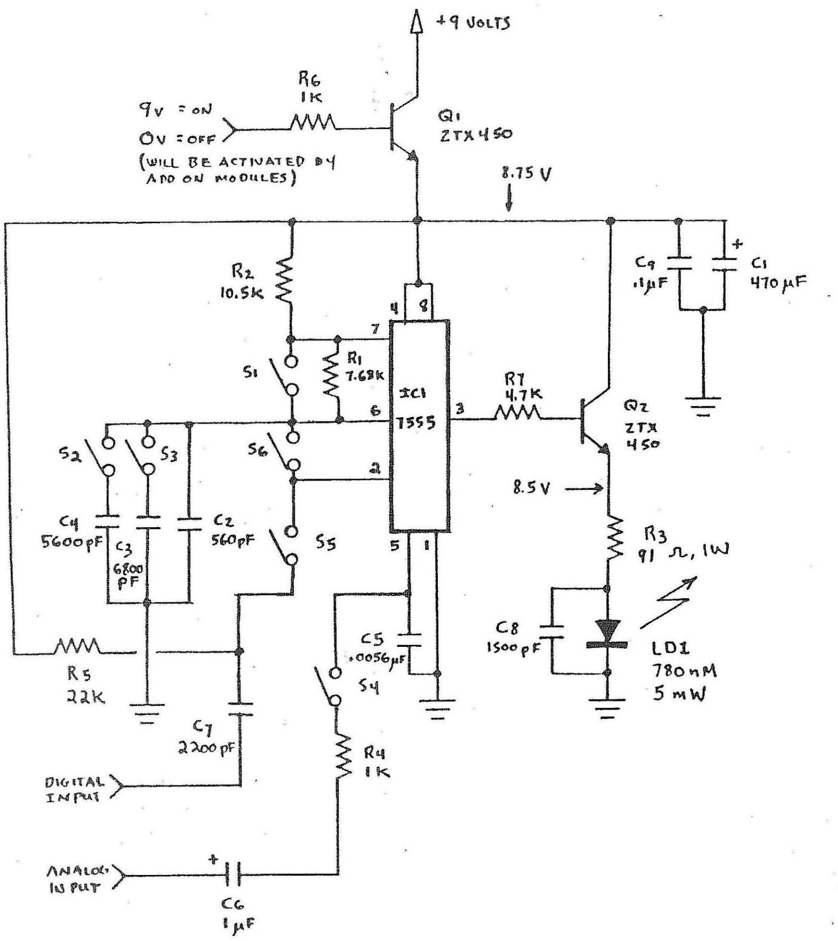
Digi-Key Corporation, 701 Brooks Avenue South, P.O. Box 677, Thief River Falls, MN 56701-0677; ph: 800-344-4539, fax: 218-681-3380. Free catalog. Top quality electronic parts supplier.

Herbach & Rademann, P.O. Box 122, 17 Canal Street, Bristol, PA 19007; ph: 215-788-5583, fax: 215-788-9577. Free catalog. An excellent experimenter source for quality mechanical, optical, electronic, and electromechanical surplus.

Images Company, P.O. Box 140742, Dept. N, Staten Island, NY 10314; ph: 718-698-8305. Carries holography supplies, optical components, components for laser power supplies.

Be sure and mention Nuts & Volts when you contact the above suppliers so your request goes to the right department.

FIGURE 3. Schematic



you wish to breadboard the circuit, keep the leads short between the laser diode and the driver transistor. Added inductance will lead to voltage spikes, so leads want to be short.

Well, we hope you will enjoy this fun little project. And there will be coverage of the various add-on modules in future columns. If you have any comments or suggestions about the Lazerwave system, please write to the Laser Experimenter P.O. Box. We appreciate all your letters . . . Have a Merry Christmas and a Happy New (Laser) Year! **NV**

Technical References:

{1} Page 48. Copyright September 1988 by Sharp Corporation

{2} From the Sharp Laser Diode User's Manual, I calculated if the emission area is .0015" by .0005", a typical size, the optical power @ 3 mW is 4 million watts per square inch. However, the chip size is greater than the area of emission. If emission covered the entire area of the chip, 250 x 125 micrometers (which it doesn't), the power density would be 51,885 watts per square inch. Therefore, I felt the estimate of "sometimes exceeding a million watts per square inch" is actually conservative.

Closing Quote: "It is possible to believe that all the past is but the beginning of a beginning, and that all that is and has been is but the twilight of the dawn? It is possible to believe that all the human mind has ever accomplished is but the dream before the awakening . . . " — H.G. Wells

Suggestions for future columns, questions, constructive criticisms and Laser related material are most welcome. Send all to: The Laser Experimenter, P.O. Box 74, Cornwall Bridge, CT 06754. We would like to publish letters in "Reader Feedback" occasionally. Indicate if using your name and address is OK. Individual replies to questions regrettably are not possible due to time constraints, but we will answer some questions in the column.

PARTS LIST

1 — Laser Light Receiver, preferably the one described in the Sept. '93 Laser Experimenter column (called LAD). Available from Allegro Electronic Systems (see "Sources").

The following semiconductor laser is recommended and available from MWK Industries (see "Sources"). It contains a laser diode, mounting frame and an adjustable optical system. Price is $40.00 plus shipping:

LD1	780 nM 5 mW infrared semiconductor laser, "sled type"	#3ANS2

NOTE: The parts below are available from Digi-Key Corp., 701 Brooks Ave. South, P.O. Box 677, Thief River Falls, MN 56701-0677. Orders under $25.00 must include a $3.00 handling charge:

IC1	CMOS 555 timer IC	#LMC555CN or 7555
Q1,Q2	ZTX450 Transistor	#ZTX450 or equivalent
C1	220 uF, 10 volt electrolytic capacitor	#P6215 or equivalent
C2	560 pF, 5% polypropylene capacitor	#P3561 or equivalent
C3	.0068 uF, 2% polypropylene capacitor	#P3682 or equivalent
C4	.0056 uF, 2% polypropylene capacitor	#P3562 or equivalent
C5	.0056 uF, 2% polypropylene capacitor	#P3562 or equivalent
C6	1 uF, 50 volt electrolytic capacitor	#P6260 or equivalent
C7	2200 pF disc	#P4189 or equivalent
C8	1500 pF disc	#P4187 or equivalent
C9	.1 uF disc	#P4311 or equivalent
R1	7.68 K Ohm, 1%, 1/4 W metal film resistor	#7.68KX or equivalent
R2	10.5 K Ohm, 1%, 1/4 W metal film resistor	#10.5KX or equivalent
R3	91 Ohm, 1 W resistor	#91W or equivalent
R4	1 K Ohm, 1/4 W resistor	
R5	22 K 1/4 W resistor	
R6	1 K Ohm, 1/4 W resistor	
R7	4.7 K Ohm, 1/4 W resistor	
S1-S6	Six position SPST DIP switch	#CT2066-ND
1	8 pin IC socket	
1	9 V alkaline battery	
1	9 V battery snap	

FIGURE 4.

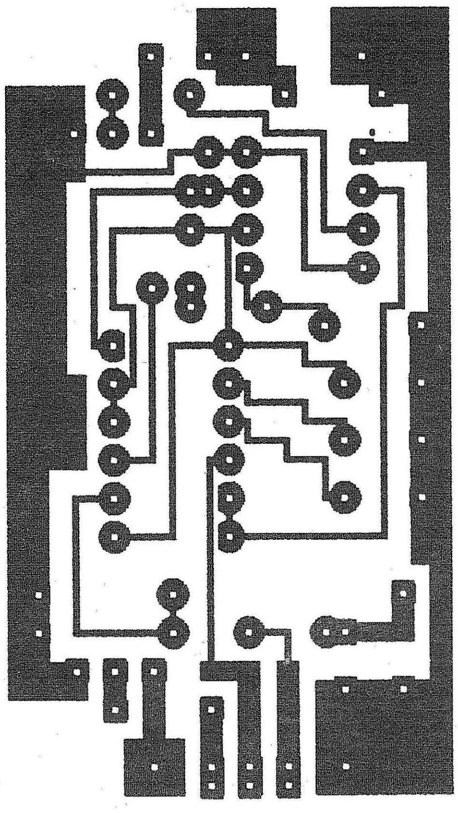
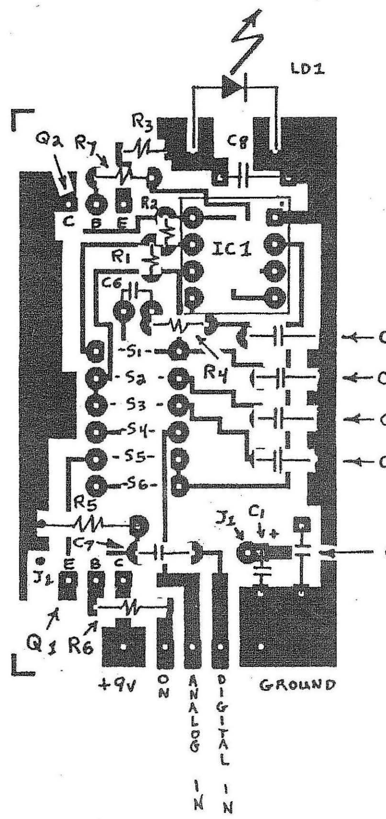


FIGURE 5.



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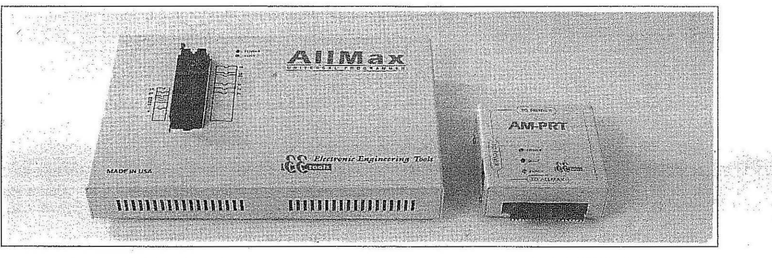

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